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(54) **TILTING TO SCROLL**

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(57)   **ABSTRACT**

In one embodiment, a method includes determining, by a computing device, a scroll range for an image based on a dimension of the image, determining the image's origin position device's initial tilt, determining a second tilt and a rate of rotation about a first axis, and determining a rate of rotation about a second axis. The method includes comparing the device's rate of rotation about the first axis with the device's rate of rotation about the second axis or one of its components. The method further includes determining, based on the comparison, whether to render a scrolling presentation of the image. When the scrolling presentation of the image is to be rendered, the method includes determining a progress parameter based on the scroll range, the origin position, the initial tilt, and the second tilt; and rendering a scrolling presentation of the image based on the progress parameter.

45 Claims, 4 Drawing Sheets
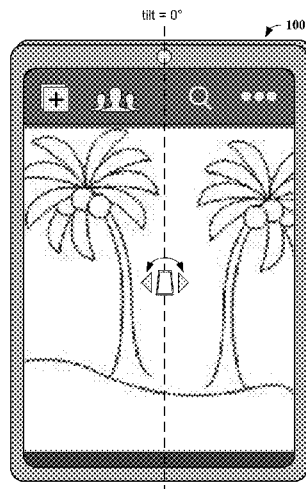
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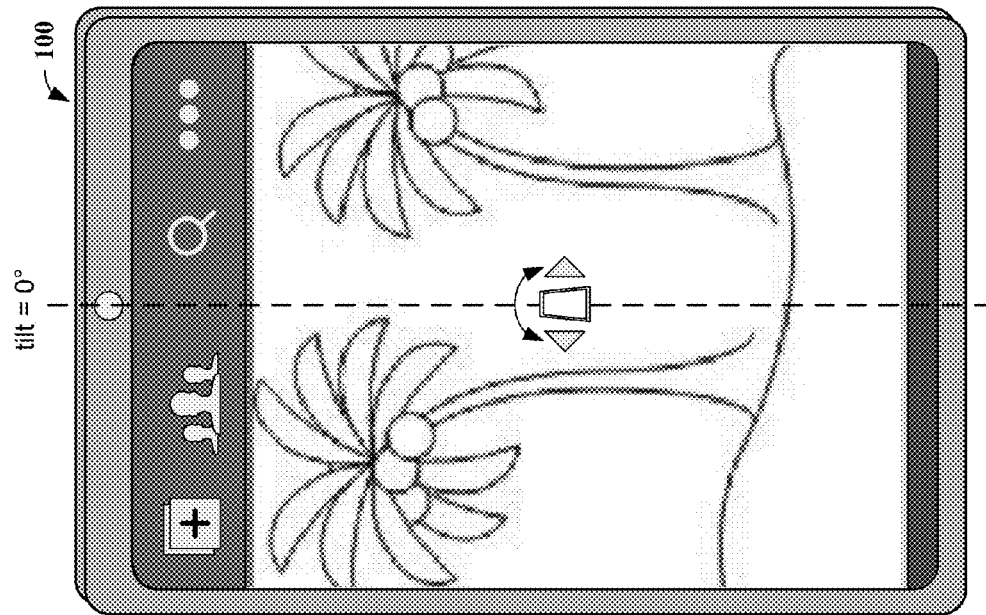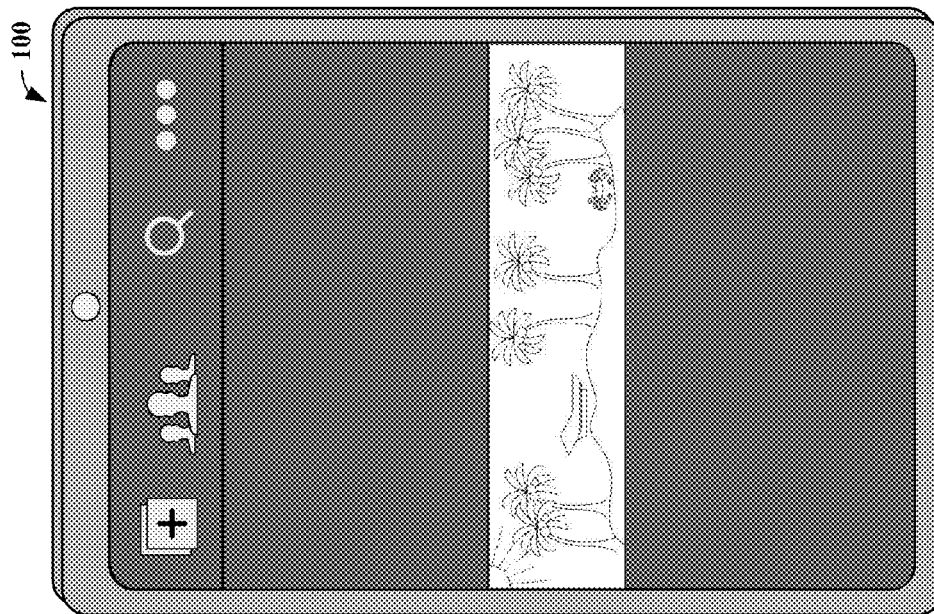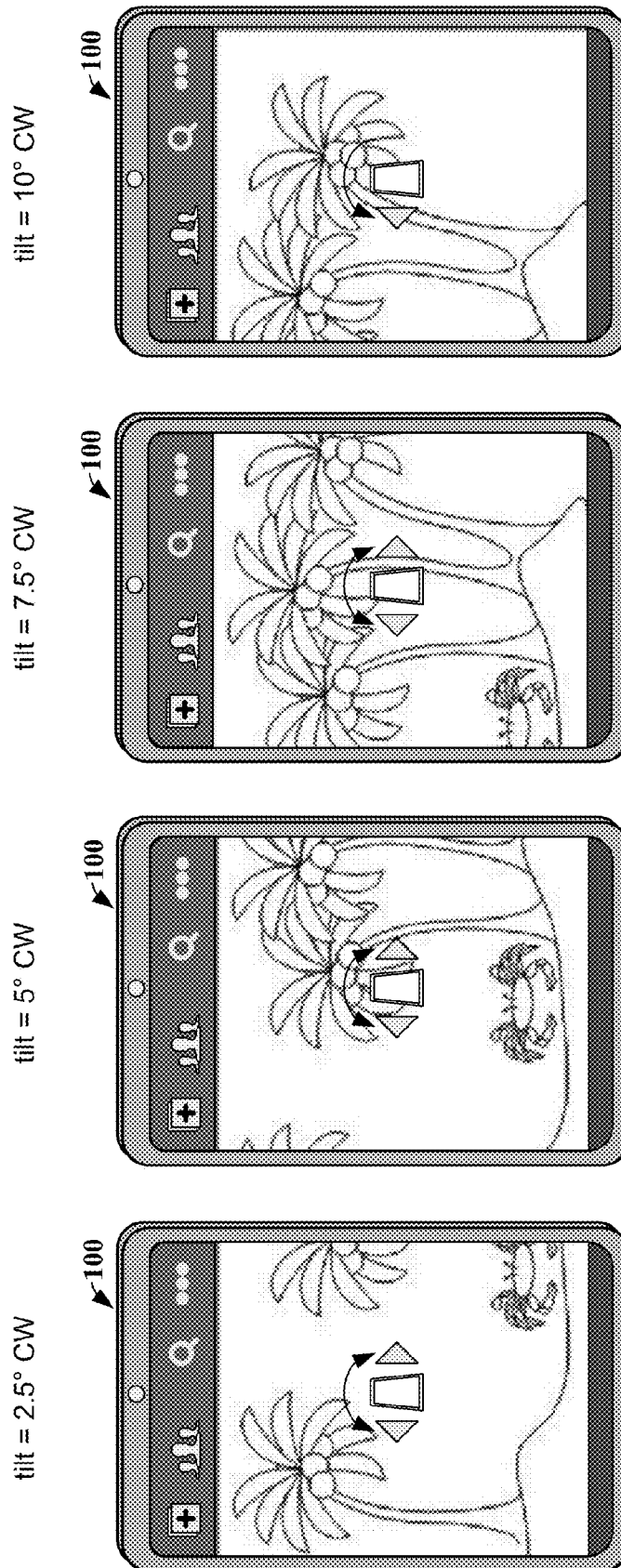
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FIG. 1B

FIG. 1A

tilt = 10° CW

FIG. 1F

tilt = 7.5° CW

FIG. 1E

tilt = 5° CW

FIG. 1D

tilt = 2.5° CW

FIG. 1C

200

210 — Present an image for display

220 — Determine a scroll range for the image

230 — Measure tilt using a gyroscope sensor

240 — Determine an origin position

250 — Determine, based on one or more factors, whether to update the image presentation

260 — Calculate, based on the input from the sensor(s) and the dimensions of the image, a progress parameter

270 — Update image presentation according to the progress parameter

290 — Receive input to re-calibrate origin position

285 — Receive input returning image to its origin position

280 — Receive an indication that the sensor(s) continue to detect movement

FIG. 2

COMPUTER SYSTEM

— 300

312 —

PROCESSOR — 302

MEMORY — 304

STORAGE — 306

I/O INTERFACE — 308

COMMUNICATION INTERFACE — 310
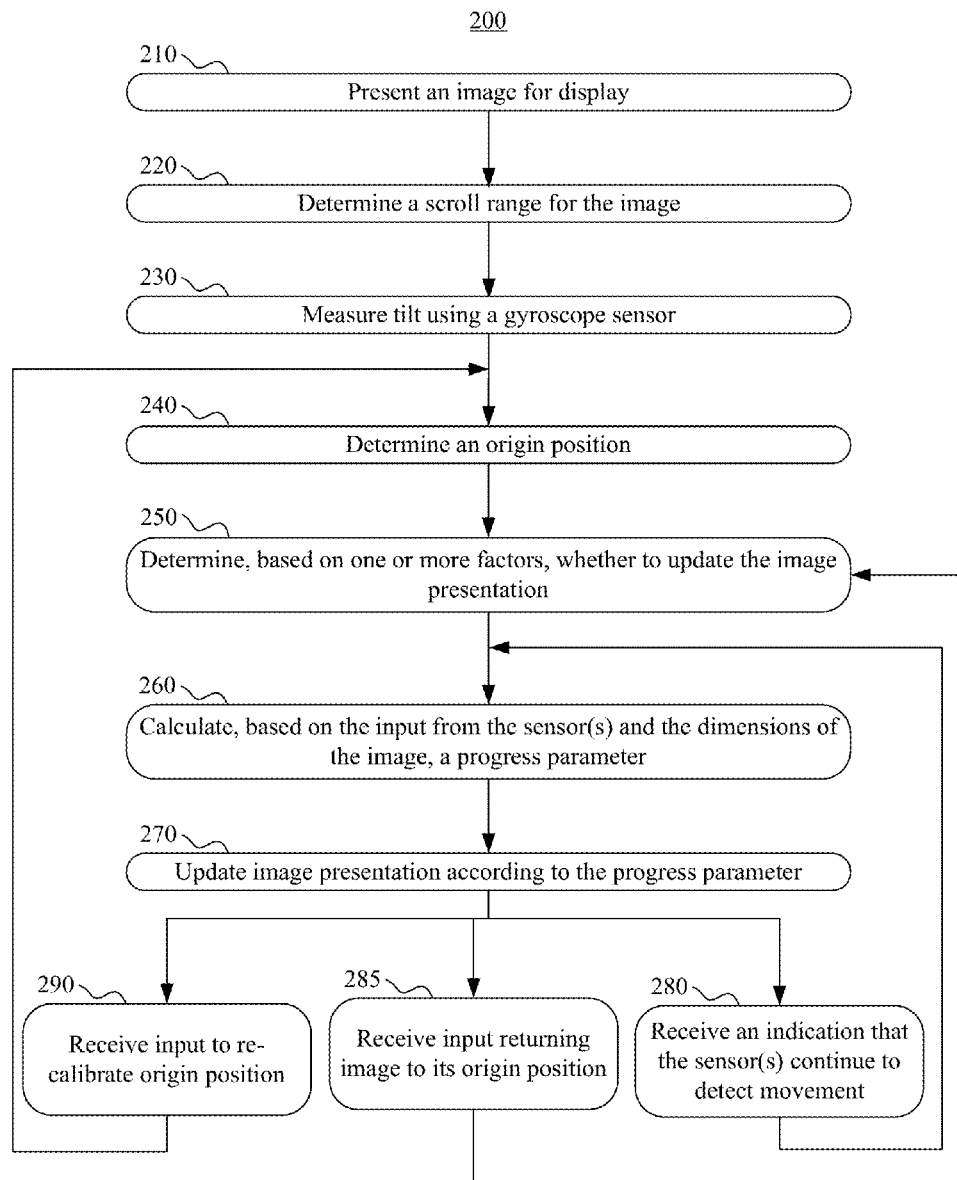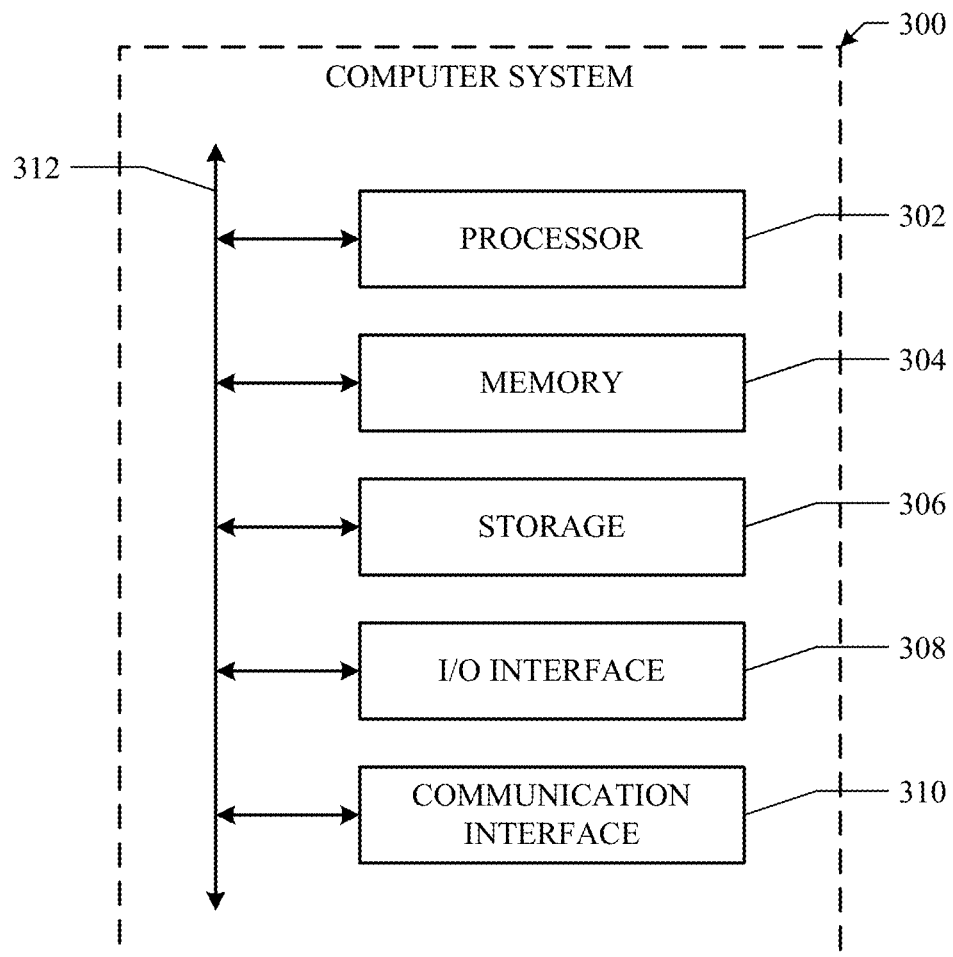
FIG. 3

TILTING TO SCROLL

TECHNICAL FIELD

This disclosure generally relates to displaying content on an electronic device.

BACKGROUND

A mobile computing device—such as a smartphone, tablet computer, or laptop computer—may include functionality for determining its location, direction, or orientation, such as a GPS receiver, compass, gyroscope, or accelerometer. Such a device may also include functionality for wireless communication, such as BLUETOOTH communication, near-field communication (NFC), or infrared (IR) communication or communication with a wireless local area networks (WLANs) or cellular-telephone network. Such a device may also include one or more cameras, scanners, touchscreens, microphones, or speakers. Mobile computing devices may also execute software applications, such as games, web browsers, or social-networking applications. With social-networking applications, users may connect, communicate, and share information with other users in their social networks.

SUMMARY OF PARTICULAR EMBODIMENTS

When an image is displayed on a screen that is not big enough to display the whole of the image at once, particular embodiments may enable a user to scroll the image in one or more directions, along one or more axes, by using a tilting motion. The image may comprise any visual content that can be displayed on the screen, including, by way of example and not limitation, a photo, a number of photos represented as a photo album, a list of emails, a web page, a map, a visual representation of a library of music, a video game, or a technical diagram.

The computing device may determine a scroll range for the image, measure initial tilt according to one or more orientation sensors (such as for example a gyroscope), and determine an origin position for the image. When the computing device determines that the presentation of the image should be updated on the display the computing device calculates a progress parameter based on the input from the sensor(s) and the scroll range, and updates the presentation of the image based on the progress parameter. As the computing device continues to receive indications from the sensor(s) that movement is detected, the computing device continues to update presentation of the image appropriately. The computing device may also receive user input to re-calibrate the origin position, at which point scrolling may continue based on the new origin position.

A determination that the presentation of an image should be updated may be based on a comparison of the rate of rotation of the device about a first axis (such as, for example, the axis about which the initial tilt is measured) with the rate of rotation of the device about a second axis (such as for example an axis orthogonal to the first axis) or a component of the second axis. For example, the ratio of the rate of rotation of the second axis to the rate of rotation about the first axis may be compared to a threshold, and if the ratio exceeds the threshold, the presentation of the image may not be updated. A determination that the presentation of an image should be updated may be based on a variable threshold that varies with the acceleration of the device, for example by increasing when the acceleration of the device increase and decreasing when the acceleration of the device decreases. The threshold

may correspond to any suitable characteristic of the motion of the device, such as for example the ratio described above.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-F are wireframes illustrating scrolling an image according to particular embodiments disclosed herein.

FIG. 2 illustrates an example method for scrolling an image according to particular embodiments disclosed herein.

FIG. 3 illustrates an example computer system.

DESCRIPTION OF EXAMPLE EMBODIMENTS

When an image is displayed on a screen that is not big enough to display the whole of the image at once, particular embodiments may enable a user to scroll the image in one or more directions by using a tilting motion. The image may comprise any suitable visual content that can be displayed on the screen, including, by way of example and not limitation, a photo, a number of photos represented as a photo album, a list of emails, a web page, a map, an advertisement, a visual representation of a library of music, a video game, a movie or other streamlining graphical content, or a technical diagram.

The computing device may determine a scroll range for the image, measure initial tilt according to any suitable orientation sensor, such as a gyroscope, magnetometer, or accelerometer. The computing device may determine an origin position for the image. Once the computing device receives an indication from an orientation sensor that a threshold for activating scrolling has been satisfied, the computing device calculates a progress parameter, based on the input from the sensor(s) and the scroll range. The computing device then updates the presentation of the image based on the progress parameter. As the computing device continues to receive indications from the sensor(s) that movement is detected, the computing device continues to update presentation of the image appropriately. The computing device may also receive user input to re-calibrate the origin position, at which point scrolling may continue based on the new origin position.

FIGS. 1A-F are wireframes illustrating an example use case of scrolling an image according to particular embodiments disclosed herein. As shown in FIG. 1A a user may use a computing device, such as a smartphone, to view a panoramic photo of a beach scene that, when resized so that the whole image appears on the screen, may be smaller than is desired. Embodiments of a computing device are described in further detail with respect to FIG. 3. The user may be able to zoom in on the image so that the complete vertical extent of the image fills the whole display region, as illustrated in FIG. 1B. At this point, the user can tilt the smartphone from side to side along an axis (such as for example the vertical axis shown as a dotted line in FIG. 1B) in the plane of the image to scroll back and forth through the panoramic image and view the entirety of the panoramic image from the left edge of the image to the right edge of the image and vice versa. As another example, a user may use the smartphone to view a list of contacts and tilt the smartphone up and down along another axis (such as for example a horizontal axis planar to the image) to scroll the list of contacts. In another example, a user may use the smartphone to view a map and tilt the smartphone in any direction along any suitable axis, such as a horizontal axis and/or a vertical axis planar to the display screen to scroll the map. Within the scope of this disclosure, "tilting" refers to any motion that may be measured by a suitable orientation sensor, and measurement of "tilt" refers to any measurements of roll, pitch, yaw, or any combination thereof that may be measured by the sensor. Although some embodiments

described herein may refer to a single axis around which tilting may occur, this disclose contemplates tiling around any suitable axis or set of axes.

In particular embodiments, as shown in the example illustrated in FIG. 1B, when the image is displayed (immediately after the zoom-in command is received), the photo is presented so as to be centered with respect to the overall panoramic image—this example origin position is the position in the image from which scrolling may commence. In particular embodiments, the origin position may be set at some position in the image in accordance with a particular application. For example, in an application where the user is asked to browse through a panoramic image of a shelf of books at a library to find one or more particular books by visual recognition, the origin position may be set at the left edge of the image. In another example, for a list of contacts, the origin position may be set at the top of the list, or at the first entry in the contact list for a selected letter of the alphabet, from which the user may scroll down (and back up). In particular embodiments, the origin position may be set at some position in the image in accordance with a user selection. For example, when displaying a map of the United States, the origin position may be set at a location selected by the user (e.g., the Grand Canyon region), from which the user may scroll around the map in any direction. In particular embodiments, the origin position may be set at any appropriate position in the image in accordance with relevant factors.

In particular embodiments, as indicated by the example illustrated in FIG. 1B, when the image is displayed (again, immediately after the zoom-in command is received), the computing device may also display a visual indicator encouraging the user to begin scrolling and/or notifying the user that such a feature is available. The indicator may indicate in which direction(s) scrolling is possible—as shown in FIG. 1B, scrolling is possible in both directions, while in FIG. 1F, scrolling is only possible in one direction (since the edge of the image has been reached).

FIGS. 1C-F illustrate an example of scrolling a zoomed-in display of the panoramic photo of FIG. 1A, starting from the origin position and an example initial tilt of 0° about a tilt axis, as shown in FIG. 1B. As shown in FIGS. 1C-F, as the user commences tilting the computing device clockwise (with respect to the user holding the computing device) from an initial tilt, the computing device detects the movement by measuring a second tilt about the tilt axis. In particular embodiments, the second tilt may be measured from the initial tilt. In particular embodiments, the second tilt and the initial tilt may be measured from a reference tilt, e.g. 0°. In particular embodiments, once a threshold to activate scrolling has been satisfied (e.g., tilting the computing device beyond a minimum delta of 2° from the initial tilt in either direction, or tilting the computing device faster than a minimum rotation rate in either direction), the computing device commences scrolling the image in accordance with the measured tilt, as described more fully below. As shown in FIGS. 1C-F, as the tilt increases, the extent to which the image is scrolled may also increase until the edge of the image is reached in FIG. 1F, when the user has tilted the computing device to the degree required to reach the edge.

FIG. 2 illustrates an example method 200 for scrolling an image according to particular embodiments. The method may begin at step 210, where a computing device renders presents an image for display. In particular embodiments, the computing device may comprise a handheld device with an integrated display screen. In particular embodiments, the computing device may be connected to an external display screen. Within the scope of this disclosure, a first component is said to be connected to a second component when it is physically connected (e.g., via a wire or cord), wirelessly connected (e.g., via BLUETOOTH, Near-Field Communications (NFC), RF, or Wi-Fi), or connected through any other kind of network (e.g., a LAN, private WAN, or the Internet).

At step 220, the computing device determines a scroll range for the image with respect to an axis. In particular embodiments, the scroll range is determined based on the aspect ratio of the image as well as the absolute dimensions of the image, e.g., scrollRange=((photoWidth/photoHeight)* (DEGREES_TO_RADIANS (tiltRange)/(length/height))), where tiltRange is the degrees of tilt required to scroll from one edge of the image to the opposite edge, and length×height is the aspect ratio of the image (where length is the dimension along which scrolling may occur). The tiltRange parameter may vary in accordance with the aspect ratio of the image, so that a larger tiltRange may be used for scrolling along the length of a panoramic image with an aspect ratio of 3×1, while a smaller tiltRange may be used for scrolling along the length of a 3×3 image. In particular embodiments, tiltRange may also be constrained to ensure that the user is not required to tilt the device to such an extent that it is awkward for the user to view the screen. In particular embodiments, a scroll range may be based on the orientation of the device. For example, a device with a rectangular display may present varying portions of an image based on whether the device is being viewed in landscape or portrait mode, and thus may calculate a varying scroll range for a dimension of an image based on whether the device is being viewed in landscape or portrait mode.

At step 230, the computing device measures an initial tilt using, for example, a gyroscope sensor. The initial tilt may be the reference point from which a subsequent change in tilt is measured. For example, if a handheld computing device with an integrated gyroscope that is displaying a panoramic image with a horizontal orientation measures the tilt with respect to an axis passing through the height of the display as being 0.3°, because a user holding the device is holding it almost perfectly level, any tilt measured in relation to subsequent motion registered by the device will be measured as a delta from that initial tilt. In particular embodiments, if the overall orientation changes while the user is viewing that same image (e.g., if the user lies down on their side while using the smartphone), the computing device may update the initial tilt so as to preserve the axis for scrolling the presentation of the image with respect to the display while appropriately applying subsequent tilt measurements to determine the progress parameter, described more fully below. Any tilt measured in relation to subsequent motion registered by the device will be measured as a delta from that updated initial tilt. As indicated in the example shown in FIG. 1B, the initial tilt is measured at 0°. In particular embodiments, the computing device may comprise a handheld device with an integrated gyroscope. In particular embodiments, the computing device may be connected to an external handheld controller comprising a gyroscope.

At step 240, the computing device determines an origin position. As described above with respect to FIG. 1B, the origin position may be set at a particular position in the image in accordance with a particular application, in accordance with a user selection, or at any appropriate position in the image in accordance with relevant factors.

At step 250, the computing device determines whether to update the image presentation (such as, for example, by activating scrolling of the image) based on one or more factors. In particular embodiments, a factor may be a second tilt (i.e., the tilt(s) subsequent to the initial tilt) about an axis. For example,

the second tilt may be measured relative to the initial tilt, or relative to a reference tilt from which both the initial tilt and the second tilt are measured.

As discussed above, a threshold may be used to activate scrolling. Threshold activation may help prevent unintentional scrolling, such as by movement of the device resulting from unintentional hand tremors or from an unstable environment, such as from riding in a vehicle. In one example embodiment, the threshold may comprise a minimum change in measured tilt, with respect to the initial tilt, in either direction. In another example embodiment, the threshold may comprise a minimum rotation rate in either direction (e.g., where the scrolling function is activated by a sharp tilting flick of the computing device.)

In particular embodiments, a determination of whether to update an image presentation includes comparing a rate of rotation of the device about a first axis with the rate of rotation of the device about a second axis or a component of the second axis. For example, the first axis may be an axis about which a component of an initial tilt is measured. As described above, in particular embodiments that axis may be in the plane of the image. A second axis may be any other suitable axis, such as for example an axis orthogonal to the first axis. Likewise, a component of the second axis may be any suitable component of that axis, such as for example a component orthogonal to the first axis. The second axis may be in the plan of the image, orthogonal to the first axis, and oriented along a dimension in which the image has no scroll range. The rate of rotation about the first axis and the rate of rotation about the second axis (which as used herein includes a rate of rotation about a component of the second axis, where appropriate) may be compared by determining a ratio of the rate of rotation about the second axis to the rate of rotation about the first axis. In particular embodiments, that ratio may be compared to a threshold, and if the ratio is greater than the threshold, then the image presentation is not updated. For example, if the rate of rotation about the second axis as a percentage of the rate of rotation about the first axis that is greater than a threshold (such as, for example, 0.55) then scrolling of an image may not occur.

In particular embodiments, a determination of whether to update an image presentation includes use of a variable threshold that varies based on acceleration of the device. For example, the threshold may increase when the acceleration of the device increases (i.e., more intentional tilting is required to scroll an image when the device's acceleration is relatively large). The threshold may decrease as the acceleration of the device decreases. In particular embodiments, a threshold may increase as a function of the acceleration and decrease as a (same or different) function of the acceleration between a maximum threshold and a minimum threshold. In particular embodiments acceleration may include linear acceleration (i.e. the change in magnitude of the device's velocity vector), angular acceleration, a change in the direction of the device's velocity vector, or any suitable combination thereof. A threshold may be compared to any suitable metric, such as for example a degree of tilt of the device, a rate of rotation of the device, the ratio of the rate of rotation of the device about two different axis (for example, the ratio described above), or any suitable combination thereof.

At step 260, the computing device calculates, based on the input from the sensor(s) and the scroll range, a progress parameter that indicates how to scroll the image. For example, the progress parameter may indicate the amount of scrolling to be performed, the speed at which scrolling should be performed, both, or any other suitable parameter. The progress parameter may comprise one or more attributes,

including, by way of example and not limitation, (1) the initial tilt measurement, (2) the current (i.e. second) tilt measurement reported by the orientation sensor, (3) a delta between the preceding tilt measurement reported by the gyroscope and the current tilt measurement, wherein the orientation sensor may sample measurements at intervals, (4) a rotation rate calculated based on the delta between the preceding tilt measurement reported by the orientation sensor and the current tilt measurement, (5) an offset of the origin position with respect to the absolute position as determined for the last tilt measurement, or (6) an offset of the origin position with respect to the absolute position as determined for the current tilt measurement reported by an orientation sensor. In particular embodiments, the progress parameter may be required to meet a minimum rotation rate, so as to prevent gradual changes in the user's device-holding stance from triggering scrolling.

In particular embodiments, the input may be clipped to limit the input data to the dimensions of the image (so that the user cannot scroll beyond the scroll range). In particular embodiments, the input data received from the gyroscope may be smoothed to reduce or eliminate shakiness due to hand tremors and produce a smooth scrolling motion. Smoothing the input may comprise applying a low-pass filter to the input data (to eliminate spikes in the input) and/or applying an RK4 (Runge-Kutte) solver to the input (to produce a steadily progressive and smooth scrolling motion).

At step 270, the computing device updates the image presentation to show scrolling of the image based on the progress parameter. The image presentation may include special effects, such as a virtual spring effect (e.g., the image bounces when scrolled to the edge of the image and "hits" the edge and/or the image scrolling slows down as the edge approaches and the virtual spring is stretched farther). In particular embodiments, movements of an image displayed on a screen may be simulated by attaching one end of a virtual spring to the image at the origin position and another end of the virtual spring to a position on the screen (e.g., the center of the screen, a corner of the screen, or an edge of the screen). Any number of virtual springs may be attached to an object. In particular embodiments, the movements of the object may be determined based on Hooke's law: $F=-kx$; where x is the displacement of the spring's end from its equilibrium position (e.g., a distance, in SI units: meters), F is the restoring force exerted by the spring on that end (in SI units: N or kg·m/s2), and k is a constant called the rate or spring constant (in SI units: N/m or kg/s2). When this equation holds, the behavior is said to be linear. The negative sign on the right hand side of the equation is there because the restoring force always acts in the opposite direction of the displacement (e.g., when a spring is stretched to the left, it pulls back to the right). In general, the following properties are involved in determining spring movement: mass, damping, spring stiffness, spring rest length. In some implementations, a virtual mass may be assigned to the object.

In particular embodiments, a virtual spring may have different state values based on attributes of the image being displayed. The spring may ramp from one set of state value to another, instead of cutting, to make animation sequence of the object's movements appear more natural. For example the distance between an edge of the image and the origin position may be used to determine the tightening of the springs used in the animation or the level of ramping from one set of state values to another.

In particular embodiments, a physics engine implements the algorithms that simulate spring movement. One or more virtual springs may be attached to an object. For example, if

a computing device is tilted so as to activate scrolling of an image displayed on a screen, a virtual spring may be attached to the origin position in the image. As the object moves (e.g., scrolled by the tilting motion), its movement follows the paths of the virtual spring, so that the movement of the object is animated based on the physics of the spring's movement. In particular embodiments, the algorithm may take into consideration variables such as tension, mass, damping effect, the measured tilt, etc. As an example, as the image is scrolled away from the origin position and closer to an edge (thereby stretching the spring further), the scrolling speed may slow down. Conversely, as the image is scrolled back towards the origin position, the scrolling speed may speed up. In another example, as the image scrolls away from the origin position and "hits" the edge, the image may appear to bounce upon reaching the edge.

In particular embodiments, when zooming in on an object, the object increases in size. When zooming out on an object, the object decreases in size. The changing of the object's size may be depicted in an animation sequence, where the movements of the object may be based on spring movements. In particular embodiments, as an object moves towards its final destination, the intermediate positions of the object may be interpolated based on spring movements. When the origin position is re-calibrated based on designation of a new origin position, the virtual spring may be re-attached to the new origin position.

At step 280, the computing device may receive continued indications that the sensor(s) are detecting movement as the user continues to tilt the computing device. In particular embodiments, the method of FIG. 2 may be repeated from step 260 as long as the sensor(s) detect substantially continuous movement. In particular embodiments, if the computing device detects a lack of movement for longer than a threshold period of time, or if the computing device detects that the magnitude of the motion detected by the sensor(s) has dropped below a threshold, the computing device may return to step 250 or may automatically pan through the image.

At step 285, the device receives input indicating the image should be returned to its origin position. In particular embodiments, the origin position may be the position of the image immediately prior to the predetermined movement. The input may be of any suitable type. For example, the input may be a predetermined movement of the device. As used herein, when suitable "predetermined movement" includes a movement, attributes or aspects of that movement, or both. For example, a predetermined movement may include shaking the device at a particular frequency, for a particular duration, or with a particular amount of force.

In particular embodiments, a predetermined movement may include a rotation of the device about any suitable axis, such as for example an amount of a second tilt about a tilt axis. For example, the predetermined movement may be a tilt of at least 90° relative to the initial tilt. As another example, the predetermined movement may be an amount of rotation relative to a suitable reference point, such as for example a rotation of at least 180°. As another example, a predetermined movement may include a rotation in a predetermined amount of time. In particular embodiments, a predetermined movement may include an acceleration associated with a tilt, such as for example an acceleration associated with the second tilt. For example, the predetermined movement may be a relatively high angular acceleration (such as at least 10π radians per second) of a tilt. In particular embodiments, a predetermined movement may be a movement that results in an attempt to scroll an image past a limit of the image's scroll range. In particular embodiments, a visual indicator may

notify the user that an image is about to be reoriented. For example, when an edge of a scroll range is reached, an effect such as a spring-like bouncing of the image may indicate that the image is being or is about to be reoriented.

In particular embodiments, a predetermined movement may be a movement that would otherwise scroll the image, i.e. a movement that would result in the device determining an update of the image presentation was required in step 250. For example, a second tilt about a tilt axis subsequent to an initial tilt may result in scrolling of the image, and particular aspects of the tilt (such as the degree of tilt, the rate of change of the tilt, or any other suitable aspect) may be the predetermined movement. Those predetermined movements may be used to identify movements that are not intended to scroll the image on the device, despite otherwise meeting the requirements of step 250. For example, a user may wish to display an image to a friend sitting opposite the user, and may turn the device to display the image to that friend. The rotation of the device may result in scrolling, but the degree of rotation, the speed of the rotation, a sudden stopping of the rotation or stopping of the rotation at a particular point of the rotation (e.g.,) 180°, or any combination thereof may be a predetermined movement that returns the image to its origin position, such as the origin position immediately prior to the rotation of the device. Thus, the image is displayed to the friend as it appeared to the user prior to the rotation.

In particular embodiments, reorientation occurs periodically throughout a predetermined movement. In particular embodiments, reorientation occurs at the end of a predetermined movement. For example, reorientation may occur after a predetermined time has passed since the predetermined movement has been completed. As another example, reorientation may occur after the predetermined movement has been completed and the device has been substantially stabilized for a period of time.

At step 290, the computing device may receive input to re-calibrate the origin position at a new origin position. After the user has scrolled away from the origin position to a new position, the user may re-calibrate the origin position at the new position (e.g., clicking and holding a finger down on the new position). In that case, the computing device may return to step 240 to determine the new origin position, and then continue to provide scrolling functionality, based on the new origin position. In particular embodiments,

In particular embodiments, when an image is first displayed on the screen, it may automatically pan through the image once, and then, once the pan is complete, the image may be available for scrolling by tilting the computing device. In connection with panning through images, particular embodiments may utilize one or more systems, components, elements, functions, methods, operations, or steps disclosed in U.S. patent application Ser. No. 13/676,831, entitled "Image Panning and Zooming Effect" and filed 14 Nov. 2012, which is incorporated herein by reference as an example and not by way of limitation.

Particular embodiments may repeat one or more steps of the method of FIG. 2, where appropriate. Although this disclosure describes and illustrates particular steps of the method of FIG. 2 as occurring in a particular order, this disclosure contemplates any suitable steps of the method of FIG. 2 occurring in any suitable order. Moreover, although this disclosure describes and illustrates particular components, devices, or systems carrying out particular steps of the method of FIG. 2, this disclosure contemplates any suitable combination of any suitable components, devices, or systems carrying out any suitable steps of the method of FIG. 2.

FIG. 3 illustrates an example computer system 300. In particular embodiments, one or more computer systems 300 perform one or more steps of one or more methods described or illustrated herein. In particular embodiments, one or more computer systems 300 provide functionality described or illustrated herein. In particular embodiments, software running on one or more computer systems 300 performs one or more steps of one or more methods described or illustrated herein or provides functionality described or illustrated herein. Particular embodiments include one or more portions of one or more computer systems 300. Herein, reference to a computer system may encompass a computing device, and vice versa, where appropriate. Moreover, reference to a computer system may encompass one or more computer systems, where appropriate.

This disclosure contemplates any suitable number of computer systems 300. This disclosure contemplates computer system 300 taking any suitable physical form. As example and not by way of limitation, computer system 300 may be an embedded computer system, a system-on-chip (SOC), a single-board computer system (SBC) (such as, for example, a computer-on-module (COM) or system-on-module (SOM)), a desktop computer system, a laptop or notebook computer system, an interactive kiosk, a mainframe, a mesh of computer systems, a mobile telephone, a personal digital assistant (PDA), a server, a tablet computer system, or a combination of two or more of these. Where appropriate, computer system 300 may include one or more computer systems 300; be unitary or distributed; span multiple locations; span multiple machines; span multiple data centers; or reside in a cloud, which may include one or more cloud components in one or more networks. Where appropriate, one or more computer systems 300 may perform without substantial spatial or temporal limitation one or more steps of one or more methods described or illustrated herein. As an example and not by way of limitation, one or more computer systems 300 may perform in real time or in batch mode one or more steps of one or more methods described or illustrated herein. One or more computer systems 300 may perform at different times or at different locations one or more steps of one or more methods described or illustrated herein, where appropriate.

In particular embodiments, computer system 300 includes a processor 302, memory 304, storage 306, an input/output (I/O) interface 308, a communication interface 310, and a bus 312. Although this disclosure describes and illustrates a particular computer system having a particular number of particular components in a particular arrangement, this disclosure contemplates any suitable computer system having any suitable number of any suitable components in any suitable arrangement.

In particular embodiments, processor 302 includes hardware for executing instructions, such as those making up a computer program. As an example and not by way of limitation, to execute instructions, processor 302 may retrieve (or fetch) the instructions from an internal register, an internal cache, memory 304, or storage 306; decode and execute them; and then write one or more results to an internal register, an internal cache, memory 304, or storage 306. In particular embodiments, processor 302 may include one or more internal caches for data, instructions, or addresses. This disclosure contemplates processor 302 including any suitable number of any suitable internal caches, where appropriate. As an example and not by way of limitation, processor 302 may include one or more instruction caches, one or more data caches, and one or more translation lookaside buffers (TLBs). Instructions in the instruction caches may be copies of instructions in memory 304 or storage 306, and the instruc-

tion caches may speed up retrieval of those instructions by processor 302. Data in the data caches may be copies of data in memory 304 or storage 306 for instructions executing at processor 302 to operate on; the results of previous instructions executed at processor 302 for access by subsequent instructions executing at processor 302 or for writing to memory 304 or storage 306; or other suitable data. The data caches may speed up read or write operations by processor 302. The TLBs may speed up virtual-address translation for processor 302. In particular embodiments, processor 302 may include one or more internal registers for data, instructions, or addresses. This disclosure contemplates processor 302 including any suitable number of any suitable internal registers, where appropriate. Where appropriate, processor 302 may include one or more arithmetic logic units (ALUs); be a multi-core processor; or include one or more processors 302. Although this disclosure describes and illustrates a particular processor, this disclosure contemplates any suitable processor.

In particular embodiments, memory 304 includes main memory for storing instructions for processor 302 to execute or data for processor 302 to operate on. As an example and not by way of limitation, computer system 300 may load instructions from storage 306 or another source (such as, for example, another computer system 300) to memory 304. Processor 302 may then load the instructions from memory 304 to an internal register or internal cache. To execute the instructions, processor 302 may retrieve the instructions from the internal register or internal cache and decode them. During or after execution of the instructions, processor 302 may write one or more results (which may be intermediate or final results) to the internal register or internal cache. Processor 302 may then write one or more of those results to memory 304. In particular embodiments, processor 302 executes only instructions in one or more internal registers or internal caches or in memory 304 (as opposed to storage 306 or elsewhere) and operates only on data in one or more internal registers or internal caches or in memory 304 (as opposed to storage 306 or elsewhere). One or more memory buses (which may each include an address bus and a data bus) may couple processor 302 to memory 304. Bus 312 may include one or more memory buses, as described below. In particular embodiments, one or more memory management units (MMUs) reside between processor 302 and memory 304 and facilitate accesses to memory 304 requested by processor 302. In particular embodiments, memory 304 includes random access memory (RAM). This RAM may be volatile memory, where appropriate Where appropriate, this RAM may be dynamic RAM (DRAM) or static RAM (SRAM). Moreover, where appropriate, this RAM may be single-ported or multi-ported RAM. This disclosure contemplates any suitable RAM. Memory 304 may include one or more memories 304, where appropriate. Although this disclosure describes and illustrates particular memory, this disclosure contemplates any suitable memory.

In particular embodiments, storage 306 includes mass storage for data or instructions. As an example and not by way of limitation, storage 306 may include a hard disk drive (HDD), a floppy disk drive, flash memory, an optical disc, a magneto-optical disc, magnetic tape, or a Universal Serial Bus (USB) drive or a combination of two or more of these. Storage 306 may include removable or non-removable (or fixed) media, where appropriate. Storage 306 may be internal or external to computer system 300, where appropriate. In particular embodiments, storage 306 is non-volatile, solid-state memory. In particular embodiments, storage 306 includes read-only memory (ROM). Where appropriate, this ROM

may be mask-programmed ROM, programmable ROM (PROM), erasable PROM (EPROM), electrically erasable PROM (EEPROM), electrically alterable ROM (EAROM), or flash memory or a combination of two or more of these. This disclosure contemplates mass storage **306** taking any suitable physical form. Storage **306** may include one or more storage control units facilitating communication between processor **302** and storage **306**, where appropriate. Where appropriate, storage **306** may include one or more storages **306**. Although this disclosure describes and illustrates particular storage, this disclosure contemplates any suitable storage.

In particular embodiments, I/O interface **308** includes hardware, software, or both, providing one or more interfaces for communication between computer system **300** and one or more I/O devices. Computer system **300** may include one or more of these I/O devices, where appropriate. One or more of these I/O devices may enable communication between a person and computer system **300**. As an example and not by way of limitation, an I/O device may include a keyboard, keypad, microphone, monitor, mouse, printer, scanner, speaker, still camera, stylus, tablet, touch screen, trackball, video camera, another suitable I/O device or a combination of two or more of these. An I/O device may include one or more sensors. This disclosure contemplates any suitable I/O devices and any suitable I/O interfaces **308** for them. Where appropriate, I/O interface **308** may include one or more device or software drivers enabling processor **302** to drive one or more of these I/O devices. I/O interface **308** may include one or more I/O interfaces **308**, where appropriate. Although this disclosure describes and illustrates a particular I/O interface, this disclosure contemplates any suitable I/O interface.

In particular embodiments, communication interface **310** includes hardware, software, or both providing one or more interfaces for communication (such as, for example, packet-based communication) between computer system **300** and one or more other computer systems **300** or one or more networks. As an example and not by way of limitation, communication interface **310** may include a network interface controller (NIC) or network adapter for communicating with an Ethernet or other wire-based network or a wireless NIC (WNIC) or wireless adapter for communicating with a wireless network, such as a WI-FI network. This disclosure contemplates any suitable network and any suitable communication interface **310** for it. As an example and not by way of limitation, computer system **300** may communicate with an ad hoc network, a personal area network (PAN), a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), or one or more portions of the Internet or a combination of two or more of these. One or more portions of one or more of these networks may be wired or wireless. As an example, computer system **300** may communicate with a wireless PAN (WPAN) (such as, for example, a BLUETOOTH WPAN), a WI-FI network, a WI-MAX network, a cellular telephone network (such as, for example, a Global System for Mobile Communications (GSM) network), or other suitable wireless network or a combination of two or more of these. Computer system **300** may include any suitable communication interface **310** for any of these networks, where appropriate. Communication interface **310** may include one or more communication interfaces **310**, where appropriate. Although this disclosure describes and illustrates a particular communication interface, this disclosure contemplates any suitable communication interface.

In particular embodiments, bus **312** includes hardware, software, or both coupling components of computer system **300** to each other. As an example and not by way of limitation,

bus **312** may include an Accelerated Graphics Port (AGP) or other graphics bus, an Enhanced Industry Standard Architecture (EISA) bus, a front-side bus (FSB), a HYPERTRANSPORT (HT) interconnect, an Industry Standard Architecture (ISA) bus, an INFINIBAND interconnect, a low-pin-count (LPC) bus, a memory bus, a Micro Channel Architecture (MCA) bus, a Peripheral Component Interconnect (PCI) bus, a PCI-Express (PCIe) bus, a serial advanced technology attachment (SATA) bus, a Video Electronics Standards Association local (VLB) bus, or another suitable bus or a combination of two or more of these. Bus **312** may include one or more buses **312**, where appropriate. Although this disclosure describes and illustrates a particular bus, this disclosure contemplates any suitable bus or interconnect.

Herein, a computer-readable non-transitory storage medium or media may include one or more semiconductor-based or other integrated circuits (ICs) (such, as for example, field-programmable gate arrays (FPGAs) or application-specific ICs (ASICs)), hard disk drives (HDDs), hybrid hard drives (HHDs), optical discs, optical disc drives (ODDs), magneto-optical discs, magneto-optical drives, floppy diskettes, floppy disk drives (FDDs), magnetic tapes, solid-state drives (SSDs), RAM-drives, SECURE DIGITAL cards or drives, any other suitable computer-readable non-transitory storage media, or any suitable combination of two or more of these, where appropriate. A computer-readable non-transitory storage medium may be volatile, non-volatile, or a combination of volatile and non-volatile, where appropriate.

Herein, "or" is inclusive and not exclusive, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A or B" means "A, B, or both," unless expressly indicated otherwise or indicated otherwise by context. Moreover, "and" is both joint and several, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A and B" means "A and B, jointly or severally," unless expressly indicated otherwise or indicated otherwise by context.

The scope of this disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments described or illustrated herein that a person having ordinary skill in the art would comprehend. The scope of this disclosure is not limited to the example embodiments described or illustrated herein. Moreover, although this disclosure describes and illustrates respective embodiments herein as including particular components, elements, feature, functions, operations, or steps, any of these embodiments may include any combination or permutation of any of the components, elements, features, functions, operations, or steps described or illustrated anywhere herein that a person having ordinary skill in the art would comprehend. Furthermore, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, component, whether or not it or that particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative.

What is claimed is:

1. A method comprising:

by a computing device, determining a scroll range for an image for display on the device, the scroll range based at least in part on a dimension of the image;

by the computing device, determining an origin position of the image and an initial tilt of the device;

by the computing device, determining a second tilt and a rate of rotation about a first axis;

by the computing device, determining a rate of rotation about a second axis;

by the computing device, determining a ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis;

by the computing device, comparing the ratio to a predetermined non-zero threshold ratio;

by the computing device, determining, based on the comparison, whether to render a scrolling presentation of the image; and

by the computing device, when the scrolling presentation of the image is to be rendered:

determining a progress parameter based at least in part on the scroll range, the origin position, the initial tilt, and the second tilt; and

rendering a scrolling presentation of the image based at least in part on the progress parameter.

2. The method of claim **1**, wherein the progress parameter is determined substantially concurrently with one or more of:

determining the rate of rotation about the second axis;

determining the ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis; or

determining, based on the comparison, whether to render the scrolling presentation of the image.

3. The method of claim **1**, wherein one or both of:

the second axis; or

the component of the second axis,

is orthogonal to the first axis.

4. The method of claim **1**, wherein determining, based on the comparison, whether to render the scrolling presentation of the image comprises

determining, when the ratio is greater than the predetermined threshold ratio, that the scrolling presentation should not be rendered.

5. The method of claim **4**, wherein the predetermined ratio has a value of approximately 0.55.

6. The method of claim **1**, wherein the first axis comprises an axis in the plane of the image and orthogonal to a third axis along which the image has a nonzero scroll range.

7. The method of claim **6**, wherein the second axis is the third axis.

8. The method of claim **1**, wherein the scroll range depends on the orientation of the device.

9. The method of claim **1**, wherein determining, based on the comparison, whether to render the scrolling presentation of the image comprises determining whether to render the scrolling presentation of the image based on:

the comparison; and

a variable threshold that varies based on an acceleration of the device.

10. The method of claim **9**, wherein the threshold increases when the acceleration of the device increases.

11. The method of claim **9**, wherein the acceleration comprises linear acceleration.

12. The method of claim **9**, wherein the threshold varies between a minimum threshold and a maximum threshold.

13. The method of claim **9**, wherein the threshold corresponds to a degree of tilt.

14. The method of claim **9**, wherein the threshold corresponds to a rate of rotation of the device.

15. The method of claim **9**, wherein the variable threshold is the predetermined threshold.

16. One or more computer-readable non-transitory storage media embodying software that is operable when executed to

determine a scroll range for an image for display on the device, the scroll range based at least in part on a dimension of the image;

determine an origin position of the image and an initial tilt of the device;

determine a second tilt and a rate of rotation about a first axis;

determine a rate of rotation about a second axis;

determine a ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis;

compare the ratio to a predetermined non-zero threshold ratio;

determine based on the comparison, whether to render a scrolling presentation of the image; and

when the scrolling presentation of the image is to be rendered:

determine a progress parameter based at least in part on the scroll range, the origin position, the initial tilt, and the second tilt; and

render a scrolling presentation of the image based at least in part on the progress parameter.

17. The media of claim **16**, wherein the software that is operable when executed to determine, based on the comparison, whether to render the scrolling presentation of the image comprises software that is operable when executed to determine whether to render the scrolling presentation of the image based on:

the comparison; and

a variable threshold that varies based on an acceleration of the device.

18. The media of claim **17**, wherein the variable threshold is the predetermined threshold.

19. The media of claim **17**, wherein the threshold increases when the acceleration of the device increases.

20. The media of claim **17**, wherein the acceleration comprises linear acceleration.

21. The media of claim **17**, wherein the threshold varies between a minimum threshold and a maximum threshold.

22. The media of claim **17**, wherein the threshold corresponds to a degree of tilt.

23. The media of claim **17**, wherein the threshold corresponds to a rate of rotation of the device.

24. The media of claim **16**, wherein the progress parameter is determined substantially concurrently with one or more of:

determining the rate of rotation about the second axis;

determining the ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis; or

determining, based on the comparison, whether to render the scrolling presentation of the image.

25. The media of claim **16**, wherein one or both of:

the second axis; or

the component of the second axis, is orthogonal to the first axis.

26. The media of claim **16**, wherein the software is further operable when executed to determine, when the ratio is greater than the predetermined threshold ratio, that the scrolling presentation should not be rendered.

27. The media of claim **26**, wherein the predetermined ratio has a value of approximately 0.55.

28. The media of claim **16**, wherein the first axis comprises an axis in the plane of the image and orthogonal to a third axis along which the image has a nonzero scroll range.

29. The media of claim **28**, wherein the second axis is the third axis.

30. The media of claim **16**, wherein the scroll range depends on the orientation of the device.

31. A system comprising:

one or more processors; and

a memory coupled to the processors comprising instructions executable by the processors, the processors being operable when executing the instructions to:

    determine a scroll range for an image for display on the device, the scroll range based at least in part on a dimension of the image;

    determine an origin position of the image and an initial tilt of the device;

    determine a second tilt and a rate of rotation about a first axis;

    determine a rate of rotation about a second axis;

    determine a ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis;

    compare the ratio to a predetermined non-zero threshold ratio;

    determine based on the comparison, whether to render a scrolling presentation of the image; and

    when the scrolling presentation of the image is to be rendered:

        determine a progress parameter based at least in part on the scroll range, the origin position, the initial tilt, and the second tilt; and

        render a scrolling presentation of the image based at least in part on the progress parameter.

32. The system of claim **31**, wherein the processors that are operable when executing the instructions to determine, based on the comparison, whether to render the scrolling presentation of the image comprise processors that are operable when executing to the instructions to determine whether to render the scrolling presentation of the image based on:

    the comparison; and

    a variable threshold that varies based on an acceleration of the device.

33. The system of claim **32**, wherein the threshold increases when the acceleration of the device increases.

34. The system of claim **32**, wherein the acceleration comprises linear acceleration.

35. The system of claim **32**, wherein the threshold varies between a minimum threshold and a maximum threshold.

36. The system of claim **32**, wherein the threshold corresponds to a degree of tilt.

37. The system of claim **32**, wherein the threshold corresponds to a rate of rotation of the device.

38. The system of claim **32**, wherein the variable threshold is the predetermined threshold.

39. The system of claim **31**, wherein the progress parameter is determined substantially concurrently with one or more of:

    determining the rate of rotation about the second axis;

    determining the ratio of the rate of rotation of the device about the second axis or about a component of the second axis to the rate of rotation of the device about the first axis; or

    determining, based on the comparison, whether to render the scrolling presentation of the image.

40. The system of claim **31**, wherein one or both of:

    the second axis; or

    the component of the second axis, is orthogonal to the first axis.

41. The system of claim **31**, wherein the processors are further operable when executing the instructions to determine, when the ratio is greater than the predetermined threshold ratio, that the scrolling presentation should not be rendered.

42. The system of claim **41**, wherein the predetermined ratio has a value of approximately 0.55.

43. The system of claim **31**, wherein the first axis comprises an axis in the plane of the image and orthogonal to a third axis along which the image has a nonzero scroll range.

44. The system of claim **43**, wherein the second axis is the third axis.

45. The system of claim **31**, wherein the scroll range depends on the orientation of the device.

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